Monsoon Disturbances Over Southeast and East Asia and the Adjacent Seas

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LONG TERM GOALS

To study weather disturbances over the Southeast and East Asian monsoon region and adjacent seas using Navy operational analysis and forecast models. The primary goal is to advance the understanding of the weather-producing systems in the region, in order to improve forecast capabilities.

OBJECTIVES

The objectives are: (1) to study the structure and the dynamic and thermodynamic properties of the disturbances in the vicinity of the Southeast and East Asian monsoon region that stretches from Indian Ocean to the tropical western Pacific, including the South China Sea and Yellow Sea, which are of particular interest to naval operations; and (2) to study the ability and sensitivity of Navy operational numerical models in analyzing and predicting these disturbances.

APPROACH

Observational studies/Data analysis: Use archived gridded data from global NWP outputs (including NOGAPS and NCEP model analyses) and satellite data to determine the structure of mesoscale and synoptic disturbances in various local regions for the different seasons. Use composite and principal component approaches to perform statistical analysis of the data.

Dynamic modeling: Use dynamic models to study the interaction of western tropical Pacific monsoon circulation and synoptic tropical disturbances.

Numerical modeling: Perform sensitivity and simulation studies of the observed monsoon disturbances with Navy's regional research and operational models. Cold start with NOGAPS fields and continued integration using update cycles. Carry out sensitivity studies with respect to physical parameterizations, grid sizes, and data impacts. Verify model forecasts and analyze model results with results of observational study using diagnostic tools.

WORK COMPLETED

Aanalyzed NOGAPS wind fields and satellite and radar images during the development of Typhoon Vamei of 27 December 2001 near Singapore and compared with theoretical model results of cross-equatorial monsoon surges. Started collection and processing of GMS Tbb data and NCEP reanalysis

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14. ABSTRACT
To study weather disturbances over the Southeast and East Asian monsoon region and adjacent seas using Navy operational analysis and forecast models. The primary goal is to advance the understanding of the weather-producing systems in the region, in order to improve forecast capabilities.

15. SUBJECT TERMS

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data to prepare for a statistical study of cyclonic circulation in the vicinity of Borneo and southern South China Sea.

RESULTS

Observational evidence suggested that Vamei formed as a result of an interaction between two well-known features of the Asian winter monsoon: A weak Borneo vortex that drifted into, and remained in, the southern tip of the South China Sea; and a strong and persistent cold surge that created the large background cyclonic vorticity at the equator (Chang *et al*. 2003). A similar equatorial generation process has been proposed two decades ago by Lim and Chang (1981), using the framework of equatorial wave theory. In their theory, geostrophic adjustment and potential vorticity conservation following a cross-equatorial surge spin up counterclockwise rotation to the east of the surge axis, where in the real world the Borneo vortex is located. A comparison of Vamei's formation with the theoretical result is summarized in Fig. 1 below.

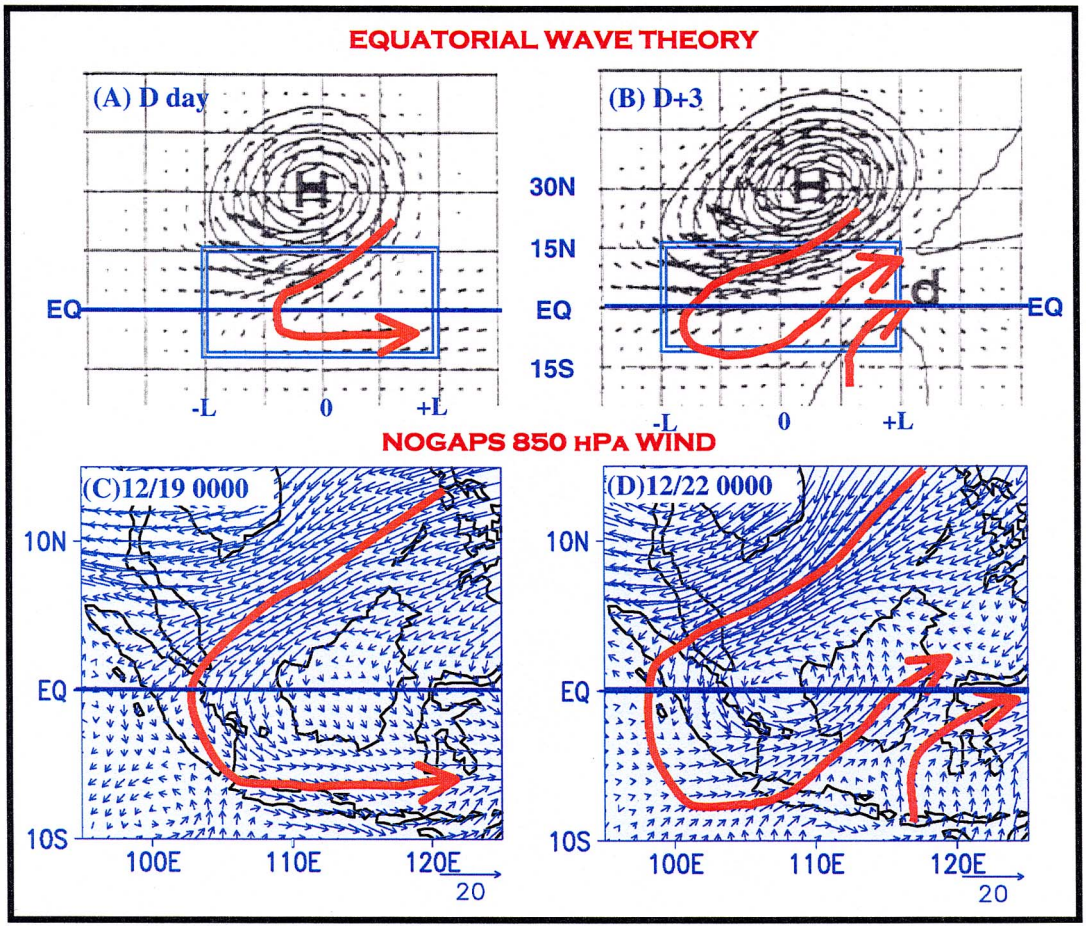

Fig. 1. Vorticity generation at the equator calculated by Lim and Chang (1981) from barotropic equatorial beta-plane solutions. (A) An equatorward surge is initiated by a high-pressure anomaly centered at 30°N, which resembles the typical cold surge event that follows the southeastward movement of an East Asian surface high center. As the northeasterly wind strengthens south of the high center, it streams southward, and after crossing the equator, it turns eastward between the equator and 15°S. At this stage, the pressure-wind pattern is adjusting toward geostrophic balance. (B) Three days later, a marked northeast-southwest tilt develops in the tropics. To the southeast of the northeasterly surge streak, southwesterly cross-equatorial winds produce a wave (area d) as they swing back south to merge with the equatorial easterlies. The area between the surge streak and area d is a northeast-southwest oriented counter-clockwise circulation belt over the equator. The flow pattern (west of the equatorial easterlies) is mainly the manifestation of a dispersive Rossby wave group. The lower two panels show the Navy Operational Global Atmospheric Prediction System (NOGAPS) 850 hPa wind analysis at (C) the beginning (19 December) of surge, and (D) three days later (22 December). Because of the narrow width of the South China Sea, the width of the intense surge belt is confined to about 750 km, which is approximately one half of that in the equatorial beta-plane solution in panel B that does not have any terrain restriction. Thus, a comparison of the theory and the actual development may be made by scaling the east-west dimension of the upper panels to one half of the original size (L = 15° longitude instead of 30°), or treating the highlighted rectangular area in (A) and (B) as being comparable to the domain of the NOGAPS plots. The location of the high center in panel (B) was also shifted eastward by 0.4 L to account for the slower propagation due to reduced zonal scale and two factors in the real world. The eastward movement of the East Asian surface high center, and the fixed location of the surge belt that is restricted geographically by the South China Sea.

IMPACT

This study was motivated by a Navy operational problem –Typhoon Vamei caused damages to USS Carl Vinson and an accompanying ship, but the research attracted wider scientific interest. The rare occurrence of this equatorial tropical cyclone and its unusual development mechanism led to a number of news reports of Chang et al. (2003) in both the scientific community and the mass media, including: **AGU Journal Highlights*: "The "perfect" equatorial typhoon" by Harvey Leifert on 3/26/03; **Associated Press*: "Scientists dissect rare typhoon near Equator" by Randolph Schmid, (reported in *USA TODAY* on 4/5/03 and other newspapers in US and abroad April-July 2003); **SCIENCE Now*: "The Rarest Typhoon" by Robert Irion on 4/8/03; **Boston Globe*: "The Lord Of The Gourd" by Agnieszka Biskup on 4/22/03; **JPL Earth Science*: "Breaking the Typhoon Rules" by Rosemary Sullivant on 4/29/03; **NSF Highlights*: "Hurricane at the Equator" by Cheryl Dybas on 5/12/03; **Taiwan Journal*: "Scientists explain anomalous Typhoon Vamei" by Myra Lu on 7/25/03; and **WeatherWise*: "The Improbable Typhoon" by Lynn Elsey in the July-August 2003 issue.

RELATED PROJECTS

NSF Project on West Pacific Monsoon Dynamics at NPS.

SUMMARY

The development of Typhoon Vamei 2001 could be related to the adjustment process of the cold surge in the South China Sea through the interaction between cross-equatorial surges and weak cyclonic circulations near Borneo (Borneo vortex). An observational study of the variations of Borneo vortices relative to different stages of cold surges and intra-seasonal variations is underway to prepare for numerical model simulations.

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Chang, C.-P., C.-H. Liu, and H.-C. Kuo, 2003: Typhoon Vamei: An equatorial tropical cyclone formation. *Geophys. Res. Lett*. **Vol. 30** No. 3, (10.1029/2002GL016365, 15 February 2003).

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PUBLICATIONS

Chang, C.-P., C.-H. Liu, and H.-C. Kuo, 2003: Typhoon Vamei: An equatorial tropical cyclone formation. *Geophys. Res. Lett*. **Vol. 30** No. 3, (10.1029/2002GL016365, 15 February 2003). [published]

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